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FWPCA PRESENTATIONS ORSANCO ENGINEERING COMMITTEE, MAY 13-14, 1969, MEETING (69TH) NETHERLAND HILTON HOTEL, CINCINNATI, OHIO

Richard A. Vanderhoof, et al

Federal Water Pollution Control Administration
Cincinnati, Ohio

1969

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ORSANCO ENGINEERING COMMITTEE

SIXTY-NINTH MEETING
NETHERLAND HILTON HOTEL
CINCINNATI, OHIO
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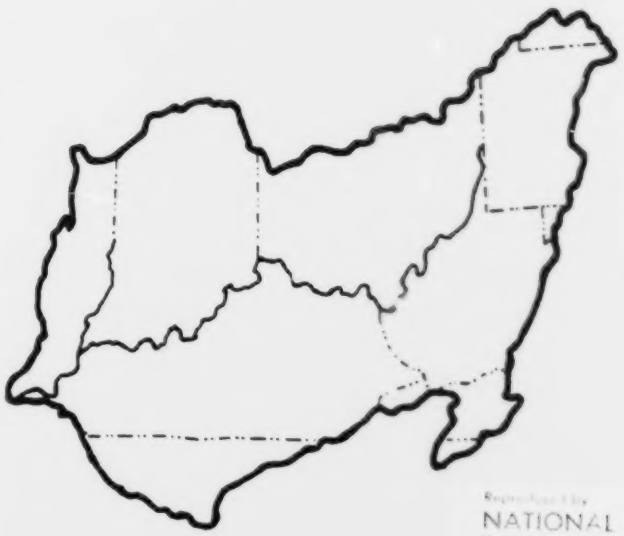

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OHIO BASIN REGION
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
UNITED STATES DEPARTMENT OF THE INTERIOR
CINCINNATI, OHIO

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I-a

C O N T E N T S

	Page
FWPCA RECOMMENDATIONS Richard A. Vanderhoof	i
ACCEPTABLE WATER QUALITY IN MIXING AREAS Kenneth M. Mackenthun	A
AQUATIC LIFE CRITERIA	
TEMPERATURE	
Present Temperature Conditions of the Ohio River Keith O. Schwab	B
Individual States Adopted Temperature Criteria Bern Wright	C
Aquatic Life Temperature Requirements Kenneth E. F. Hokanson, Ph.D.	D
DISSOLVED OXYGEN	
Present Dissolved Oxygen Conditions of the Ohio River Keith O. Schwab and Bernard Sacks	E
Individual States Adopted Dissolved Oxygen Criteria Bern Wright	F
Productivity and Seasonal Variations Related to Aquatic Life Dissolved Oxygen Requirements William A. Brungs, Ph.D.	G
pH	
Present pH Conditions of the Ohio River Keith O. Schwab	H
Individual States Adopted pH Criteria Bern Wright	I
Aquatic Life pH Requirements William A. Brungs, Ph.D.	J

IMPLEMENTATION

Implementation Plan Compliance for the Ohio River
Robert S. Burd K

RECREATION

BACTERIA

Present Bacteriological Conditions of the Ohio River
James H. Adams, Jr. L

Individual States Adopted Bacterial Criteria
Bern Wright M

RECOMMENDATIONS

R. A. Vanderhoof

SUMMARY OF CRITERIA

The objective in seeking revisions in water quality criteria is to more precisely define the necessary water quality characteristics required for a particular water use. Knowledge of realistic water quality criteria and the existing tributary water quality and uses must be resolved into attainable and enforceable standards that will be consistent with existing water quality or anticipated water quality after installation of pollution abatement measures.

The Federal Water Pollution Control Administration has reviewed the criteria for aquatic life and recreational uses relative to the Main Stem of the Ohio River. The available evidence indicates the following criteria are deemed appropriate for acceptance by ORSANCO.

AQUATIC LIFE

A. TEMPERATURE - RECOMMENDED CRITERIA

1. To maintain well-rounded warm-water biota:

   a. The water temperatures shall not exceed 90° F. (32.2°C.) at any time or any place, and a maximum hourly average value of 86°F. (30°C.) shall not be exceeded.

   b. The temperature shall not exceed the temperature values expressed on the following table:

AQUATIC LIFE TABLE

	Daily Mean, °F.	Hourly Max., °F.
Dec. - Feb.	48	55
Early March	50	56
Late March	52	58
Early April	55	60
Late April	58	62
Early May	62	64
Late May	68	72
Early June	75	79
Late June	78	82
July - Sept.	82	86
October	75	82
November	65	72

c. During any month of the year, controllable heat* shall not be added to a stream in excess of the amount that will raise the temperature of the water (at the expected minimum daily flow for that month) more than a calculated 5°F. That is, the minimum daily low flow for the month in cubic feet per second - converted to pounds per second - and multiplied by 5 shall be the maximum rate of heat addition in BTU's** per second for that month.

2. To maintain trout habitats:

a. Inland trout streams, headwaters of salmon streams, trout and salmon lakes and reservoirs, and the hypolimnion of lakes and reservoirs containing salmonids should not be warmed. No heated effluents should be discharged in the vicinity of spawning areas.

For other types and reaches of cold-water streams, reservoirs, and lakes, the following restrictions are recommended.

b. During any month of the year, heat should not be added to a stream in excess of the amount that will raise the temperature of the water more than 5°F. (based on the minimum expected flow for that month). In lakes and reservoirs, the temperature of the epilimnion should not be raised more than 3°F. by the addition of heat of artificial origin.

c. The normal daily and seasonal temperature fluctuations that existed before the addition of heat due to other than natural causes should be maintained.

d. The maximum temperatures for cold waters are expressed in the following table:

	Daily Mean, °F.	Hourly Max., °F.
October - April	50	55
September & May Transition Period	58	62
June - August	66	70

---

* Controllable heat is defined as any heat load discharged to a public body of water by an industrial source of any type.

** BTU - British Thermal Unit is defined as the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit at, or near, its point of maximum density (39.1°F.).

B. DISSOLVED OXYGEN - RECOMMENDED CRITERIA

1. Habitats for well-rounded warm water fish populations: The D.O. concentration shall average at least 5.0 mg/l per calendar day and shall not be less than 4.0 mg/l at any time or any place outside the mixing zone.

2. Habitats for cold water fish populations: The D.O. concentration shall not be less than 6 mg/l to be met at any time or at any place. Spawning areas shall be protected by a minimum 7.0 mg/l dissolved oxygen.

C. pH - RECOMMENDED CRITERIA

Recommendation:

1. No highly dissociated materials should be added in quantities sufficient to lower the pH below 6.5 or to raise the pH above 8.5. It shall be recognized that pH is a poor criterion for the expression of toxicity of acids and alkalies.

2. That the addition of ammonia (as NH_3 or NH_4OH), poorly dissociated inorganic acids and organic bases and acids shall be regulated not in terms of pH, but in terms of their own toxicities as established by bioassay.

RECREATION

A. PRIMARY CONTACT RECREATION - RECOMMENDED CRITERIA

In addition to the presently accepted and approved total coliform resolution:

> "Bacteria: Coliform group not to exceed 1,000 per 100 ml as a monthly average value (either MPN or MF count); nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 2,400 per 100 ml (MPN or MF count) on any day."

It is recommended that a resolution on fecal coliform should be proposed which follows the NTAC recommendations on recreational criteria:

> "Fecal coliforms should be used as the indicator organism for evaluating the microbiological suitability of recreation waters. As determined by

> multiple-tube fermentation or membrane filter procedures and based on a minimum of not less than five samples taken over not more than a 30-day period, the fecal coliform content of primary contact recreation waters shall not exceed a geometric mean of 200/100 ml, nor shall be more than 10 percent of total samples during any 30-day period exceed 400/100 ml."

A transition period of several years should be utilized to implement the change to fecal coliform. During this period, we recommend analysis for both total and fecal coliform organisms.

ACCEPTABLE WATER QUALITY IN MIXING AREAS

K. M. Mackenthun

As stated in the National Technical Advisory Committee Report, and to protect water quality, mixing areas must not be used for, or considered as, a substitute for waste treatment, or as an extension of, or substitute for a waste treatment facility. Mixing should be accomplished as quickly as possible through the use of devices which ensure that the waste is mixed with the allocated dilution water in the smallest possible area. At the border of the mixing area, water quality must meet water quality standards.

Mixing zones should not be permitted where serious damage may be done to a recognized aquatic resource. The location of mixing zones should be determined on a case-by-case agreement between the Federal Water Pollution Control Administration and the involved State government and/or interstate compact.

Where mixing zones are allowed, the following are recommended:

1. As a guideline, the maximum distance of the mixing zone in any direction should not exceed that obtained by multiplying the square root of the discharged number of million gallons per day times 200 feet (i.e., $\underline{25}$ mgd = $\sqrt{25}$ x 200 = 1,000 feet); and in no case exceed 3/4 mile.
2. Mixing zones for single or cumulative discharges should be limited to 25 percent of the cross-

sectional stream area, width, or volume of flow; when density differences between waste waters and receiving waters produce stratification, the stratified layer shall not extend beyond 25 percent of the width of the stream;

3. At no place in the mixing zone should the 96 hour TL_m to aquatic life be exceeded;

4. Mixing areas shall be:

   Free from substances attributable to municipal, industrial or other discharges that will settle to form putrescent or otherwise objectionable sludge deposits;

   Free from floating debris, oil, scum, and other floating materials or other discharges in amounts sufficient to be unsightly or deleterious;

   Free from discharged materials that produce color, odor, or other conditions in such degree as to create a nuisance.

   Free from substances and conditions or combinations thereof in concentrations that produce undesirable aquatic life.

PRESENT TEMPERATURE CONDITIONS OF THE OHIO RIVER

K.O. Schwab

The activities of man have altered temperature conditions in the Ohio. Clearing of trees along portions of the banks and construction of locks and dams have had an effect on temperature that is difficult to define. Somewhat more predictable is the effect on temperature of industrial thermal discharges. The major source of industrial heat loadings is from steam-electric power plants.

Exhibit B-1, based on information prepared by the Federal Power Commission, shows past and projected power consumption in the basin. Continuing rapid growth of power generation to meet human needs is a fact of life. In the Ohio Basin, electric power generation is expected to double between 1970 and 1980. Practically all of the predicted expansion will result from new thermal power installations, since most of the best hydro-electric capability has already been developed. In addition, because of the economics of scale, most of the additional capacity is expected to come from large installations of over 500-megawatt capacity.

Exhibit B-2 shows the location of the 14 present installations of over 1,000 megawatts in the basin. Nine of these are on the main stem of the Ohio River. Some of these 14 are scheduled for expansion and additional large installations will have to be constructed to meet future needs. A plant of 1,000 megawatts is capable of adding enough B.T.U.'s to raise a

flow of 5,000 cfs (the approximate 30-day, 10-year low flow of the Ohio River below Pittsburgh after augmentation by existing and planned reservoirs) by about 4°F. Plants capable of generating up to 2,600 megawatts are known to be in the planning stage in the Ohio Basin.

Exhibit B-3 shows the range of maximum hourly values by month from 1962 through 1968, as recorded on the ORSANCO robot monitors at Cincinnati and Huntington. This Exhibit also shows the median of the maximum hourly values by month.

A review of ORSANCO data allows the following general conclusions:

1. Maximum hourly values for a month generally are between 0.5° and 1.5° F above the maximum daily average.
2. At ORSANCO stations other than Cincinnati, maximum values after several years of record reach:

   Maximum hourly values ≈ 87.0 to 88.5° F

   Maximum daily average ≈ 86 to 87° F
3. At the ORSANCO Cincinnati station:

   Maximum hourly value = 85° F

   Maximum daily average = 84.4° F

Information in the Markland Pool studies of FWPCA and studies carried out on the Ohio River by the Upper Ohio Basin Office in the vicinity of Wheeling, West Virginia, show the following:

1. The river is not thermally stratified. During the 1963 Markland Pool study cross sectional temperature difference of about 0.1° C existed between the surface and a depth of 18 feet.

2. Cross-sectional differences are noticeable only in areas of thermal discharge plumes and mixing areas. Some evidence indicates that short circuiting or upstream displacement of thermally heated discharges exists where intake and discharge are in the same pool.

Exhibit B-1

Ohio River Basin Study

Past and Estimated Future Power Requirements of Utility Market Area

Year	Energy Requirements (Million Kwh)	Peak Demand (Thousand Kw)	Load Factor %
1950	42,495	7,562	64.2
1960	106,273	17,102	70.8
1963	120,227	19,709	69.6
1970	162,650	27,910	66.5
1980	315,950	53,760	67.1
1990	551,400	93,700	67.2
2000	879,500	149,000	67.4
2010	1,281,800	216,700	67.5
2020	1,725,800	290,700	67.8

From Ohio River Basin Comprehensive Survey Appendix I, Federal Power Commission; 1966

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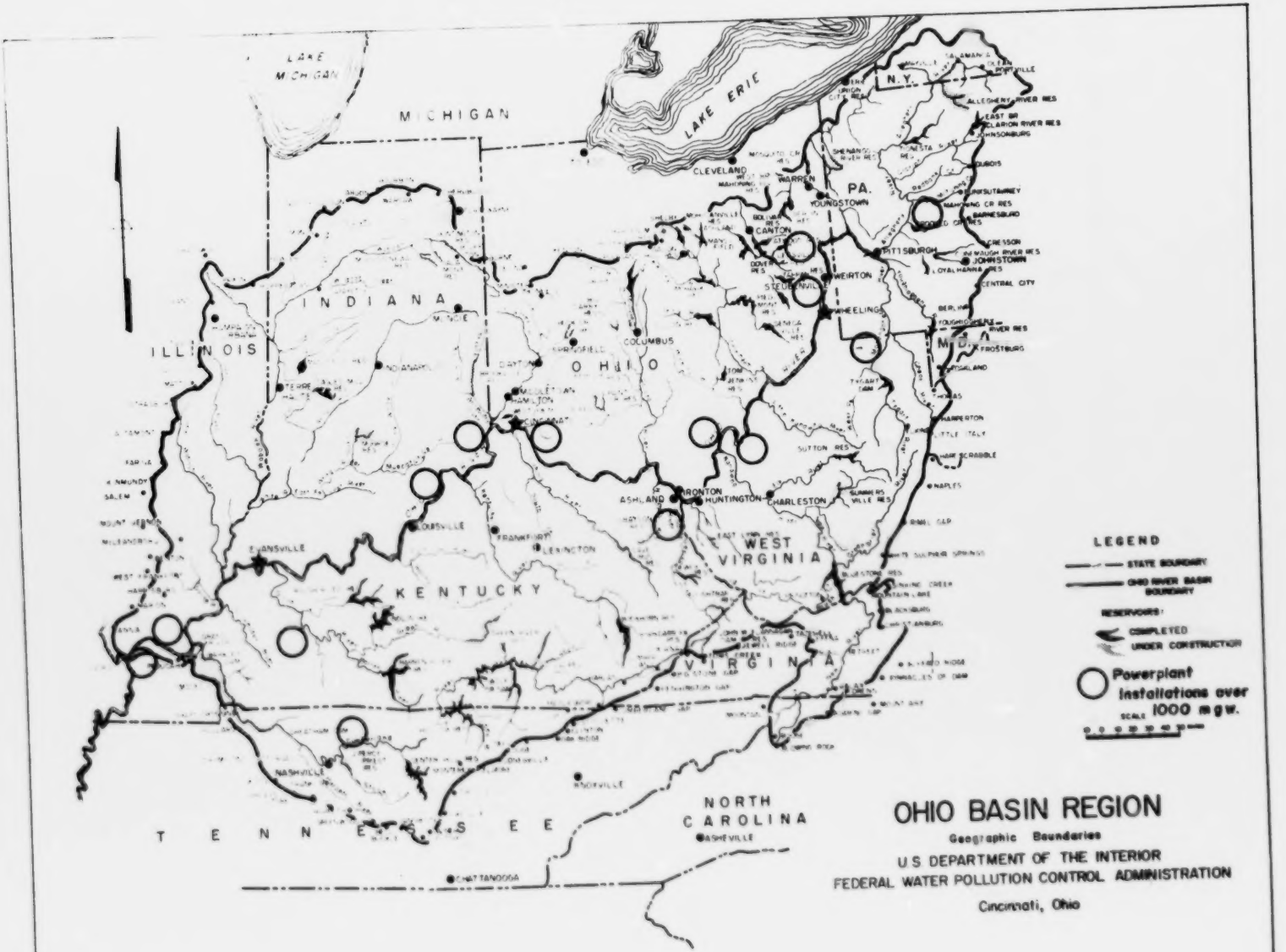

EXHIBIT B - 2

EXHIBIT B-3

MAXIMUM TEMPERATURES FROM ORSANCO ROBOT MONITORS
AT CINCINNATI, OHIO AND HUNTINGTON, W. VA. FOR
THE YEARS 1962 THROUGH 1968

	CINCINNATI				HUNTINGTON				
	Max. Hourly Value		Max. Daily Average			Max. Hourly Value		Max. Daily Average	
	Range	Median	Range	Median		Range	Median	Range	Median
Jan.	38.9-47.5	44.0	38.5-45.9	43.0	Jan.	40.8-46.8	44.0	39.9-46.3	43.1
Feb.	41.0-45.1	44.7	37.9-42.9	42.2	Feb.	40.1-46.6	45.2	38.6-44.0	40.7
Mar.	46.4-54.0	50.0	45.5-52.1	50.7	Mar.	49.2-55.6	51.6	48.2-54.0	50.7
Apr.	57.7-63.5	60.7	56.8-62.8	60.4	Apr.	62.5-66.1	63.2	61.5-65.6	62.6
May	66.9-75.3	71.1	66.3-74.6	70.2	May	69.1-79.9	74.7	68.6-78.7	73.6
June	76.3-81.4	78.5	75.4-80.9	77.7	June	79.5-84.9	81.2	78.5-83.9	80.6
July	80.3-85.0	83.5	79.5-84.4	82.2	July	84.4-88.2	85.9	84.0-86.7	85.5
Aug.	82.0-84.0	83.3	81.3-83.6	82.6	Aug.	83.9-88.3	85.5	82.7-86.8	84.6
Sept.	77.3-82.5	79.5	76.5-81.4	78.3	Sept.	76.9-81.8	79.8	76.2-81.3	79.1
Oct.	68.1-74.5	72.0	67.8-74.1	71.6	Oct.	69.3-77.1	72.6	68.5-76.5	72.1
Nov.	57.6-65.6	60.3	57.0-65.1	59.8	Nov.	56.6-65.7	61.0	56.3-64.7	60.3
Dec.	45.5-56.9	48.3	44.9-56.6	47.6	Dec.	41.1-53.8	48.7	40.6-52.9	48.0

Ohio River Valley Water Sanitation Commission

Attachment No. 2 (page 1 of 1)
Engineering Committee Agenda
May 13 and 14, 1969

Maximum Temperature Readings in the Ohio River for the Period September 1962 Through December 1968 (Degrees Fahrenheit)

MONTH	STRATTON (mile 55.0)		HUNTINGTON (mile 304.2)		CINCINNATI (mile 462.8)	
	MAX. HOURLY VALUE	MAX. DAILY-AVG. VALUE	MAX. HOURLY VALUE	MAX. DAILY-AVG. VALUE	MAX. HOURLY VALUE	MAX. DAILY-AVG. VALUE
JAN.	50.6	47.0	46.8	46.3	47.5	45.9
FEB.	42.1	40.1	46.6	44.0	44.9	42.5
MAR.	56.9	53.1	55.6	54.0	54.0	52.1

Ohio River Valley Water Sanitation Commission

Maximum Temperature Readings in the Ohio River for the Period September 1962 Through December 1968 (Degrees Fahrenheit)

MONTH	STRATTON (mile 55.0)		HUNTINGTON (mile 304.2)		CINCINNATI (mile 462.8)	
	MAX. HOURLY VALUE	MAX. DAILY-AVG. VALUE	MAX. HOURLY VALUE	MAX. DAILY-AVG. VALUE	MAX. HOURLY VALUE	MAX. DAILY-AVG. VALUE
APR.	66.5	65.9	66.1	65.6	63.5	62.8
MAY	76.7	75.8	79.9	78.7	75.3	74.6
JUNE	86.4	85.9	84.9	83.9	80.3	80.9

Ohio River Valley Water Sanitation Commission

Maximum Temperature Readings in the Ohio River for the Period September 1962 Through December 1968 (Degrees Fahrenheit)

MONTH	STRATTON (mile 55.0)		HUNTINGTON (mile 304.2)		CINCINNATI (mile 462.8)	
	MAX. HOURLY VALUE	MAX. DAILY-AVG. VALUE	MAX. HOURLY VALUE	MAX. DAILY-AVG. VALUE	MAX. HOURLY VALUE	MAX. DAILY-AVG. VALUE
JULY	88.0	86.9	88.2	86.7	85.0	84.4
AUG.	87.8	86.6	88.3	86.8	84.0	83.6
SEPT.	82.8	82.0	81.8	81.3	82.5	81.4

Ohio River Valley Water Sanitation Commission

Maximum Temperature Readings in the Ohio River for the Period September 1962 Through December 1968 (Degrees Fahrenheit)

MONTH	STRATTON (mile 55.0)		HUNTINGTON (mile 304.2)		CINCINNATI (mile 462.8)	
	MAX. HOURLY VALUE	MAX. DAILY-AVG. VALUE	MAX. HOURLY VALUE	MAX. DAILY-AVG. VALUE	MAX. HOURLY VALUE	MAX. DAILY-AVG. VALUE
OCT.	76.9	76.2	77.1	76.5	74.5	74.1
NOV.	66.8	66.1	65.7	64.7	65.6	65.1
DEC.	51.1	49.6	53.8	52.9	56.9	56.6

INDIVIDUAL STATES ADOPTED TEMPERATURE CRITERIA

B. Wright

Temperature Criteria of ORSANCO States
For Aquatic Life

STATE	CRITERIA	APPROVED
Illinois	Not to exceed 90° F at any time during the months of April through November, and not to exceed 60° F at any time during the months of December to April. Drastic or sudden temperature changes will not be permitted. The Board will insist upon controlled changes in temperature not to exceed 2° F per hour, nor more than a 5° F cumulative change from natural water temperature.	Pending Approval
Indiana	Warm water fish habitat: Not to exceed 93° F at any time during the months of April through November, and not to exceed 60° F at any time during the months of December through March. Drastic or sudden temperature changes will not be permitted. The Board will insist upon gradual changes in temperature not to exceed 2° F per hour nor more than a total change in 24 hours of the maximum dirunal change or 9° F whichever is greater. Cold water fish habitat: Not to exceed 65° F; however, slightly higher temperatures may be tolerated with higher dissolved oxygen content than specified. (Temperature change limitations same as for warm water fish habitat.)	July 18, 1967*
Kentucky	Not to exceed 93° F at any time during the months of May through November, and not to exceed 73° F at any time during the months of December through April. The maximum allowable change in temperature due to thermal load on a daily basis would be 10° F and that the maximum rate on an hourly basis would be 2° F.	Excepted from approval - March 20, 1969

* Standards are to be reviewed for consistency with present criteria recommendations

STATE	CRITERIA	APPROVED
New York	No heated liquids at such temperatures as to be injurious to fish life, . . . Technical Bulletin # 36: Stream temperatures in excess of 86° F will not be permitted after mixing. Further, no permanent change in excess of 5° F will be permitted from naturally occuring background temperatures. Temperature change rate shall be limited to 2° F per hour, not to exceed 9° F in any 24 hour period, further limited in that for any seven (7) day period the average change will meet the 5° F change of background criteria stated above. (Generally, the surface water temperature shall not exceed 90° F within the mixing zone.) No thermal discharges permitted to trout waters.	August 7, 1967 * (State is considering revision of criteria)
Ohio	Not to exceed 93° F at any time during the months of May through November, and not to exceed 73° F at any time during the months of December through April. The rate of change of temperature is limited to an increase of 5° F.	Excepted from approval - March 4, 1968
Pennsylvania	Warm water fish habitat: d_2 - Not to exceed 5° F rise above ambient temperature or a maximum of 87° F, whichever is less; not to be changed by more than 2° F during any one hour period. Cold water fish habitat: d_1 - Not to be increased by more than 5° F above natural temperature or to be increased above 58° F.	September 25, 1968

* Standards are to be reviewed for consistency with present criteria recommendations

STATE	CRITERIA	APPROVED
Virginia	Warm water fish habitat: Not to exceed 95°F, unless caused by natural conditions. No sudden temperature changes that may affect aquatic life, no thermal barriers to the passage of fish, and no affect on essential spawning areas.	Excepted from approval- January 17, 1969
	Cold water fish habitat: Not to exceed 70°F unless caused by natural conditions.	Approved - January 17, 1969, with provision that State adopt numerical temperature change limit
West Virginia	Not to exceed 93°F at any time during the months of May through November, and not to exceed 73°F at any time during months of December through April. No discharge shall raise the stream temperature more than five (5) degrees after suitable admixture above normal temperature background. The rate of change shall not exceed two (2) degrees per hour under normal operating conditions. (After suitable abatement is affected or five years from date of standards - the maximum temperature for the Ohio River will be lowered to 87°F during the months of May through November. The maximum temperature for the tributaries of the Ohio River except for Zone 11 of the Kanawha River is 87°F during the months of May through November.)	May 21, 1968

AQUATIC LIFE TEMPERATURE REQUIREMENTS

K. E. F. Hokanson

Temperature is the prime regulator of life processes because it affects the functions and activities of organisms, and it may be the most important single factor affecting aquatic life. When establishing permissible water temperatures to preserve and perpetuate aquatic life, cognizance must be taken of field and laboratory data. Because of recent increasing awareness of potential problems to aquatic life from waste heat from the growing thermal-electric generation industry, many investigators have begun recently to evaluate some of the temperature effects.

I will present some recent unpublished findings by the National Water Quality Laboratory, the Tennessee Valley Authority, the Bureau of Sport Fisheries and Wildlife, and other agencies.

The harvestable number of aquatic organisms is dependent upon the basic equation:

> Annual recruitment minus mortality (including all life stages, predation and natural death) = harvestable surplus.

For sustained yields, consideration must be made for sufficient adult carry-over to provide for new recruitment or

reproduction. Because fish are mobile, naturally occurring high temperatures are rarely a factor in natural mortalities. When free to do so, fish will seek a preferred temperature; this has long been recognized by outdoor magazines and other sportsmen publications that recommend fishing for a species at a certain depth or season based on temperature. Recent findings indicate that the lethal temperature, such as the 96 hour TLm, may have no bearing on the quality of fisheries within a waterway. The critical life stages include spawning, egg and fry development. Table D-1 presents maximum temperatures for growth, reproduction and survival for four species of fishes; it indicates that the spawning or reproduction phase is approximately 15 to 20°F. lower than the lethal temperature for these fish. If temperatures during the critical recruitment phase of the fisheries population is above maximum specified levels, there will be no recruitment and a fishery will not be sustained. Table D-2 presents some maximum temperatures for reproduction for fish present in the Ohio River drainage basin. Included are several non-game or forage fish that serve a very important role as the basis of the food supply for harvestable basses, sauger or jack salmon, and catfish. Generally, fish that spawn in early spring have lower temperature requirements than those that spawn in summer. This emphasizes a need for maintaining the seasonal temperature cycle. If these temperatures

are exceeded during the spawning season, there will be no recruitment and eventually the species will become extinct even though adults may thrive in these waters.

After the eggs have hatched and the fry have grown to fingerling size, fish will prefer somewhat higher temperatures which allow for optimum growth and activity (Table D-3). None of the Ohio River fish listed have their best growth potential at temperatures above 86°F.

Table D-4 presents a summary of lethal temperature limits of some Ohio River fishes. Should water temperatures be increased or decreased gradually (few °F/hour) or suddenly beyond the limits set by the acclimation temperature, fish fatalities may be expected. Only slow rates of change (few °F/day) will allow complete acclimation, which proceeds slowly at colder temperatures, and changes in fish tolerance limits. There is a range of tolerances among species; but the fathead minnow, an important forage fish, will die when the temperature is raised suddenly, 6° to 92°F. when acclimated to a temperature of 86°F. This same species can tolerate a sudden rise of 33° when acclimated to 50°F. which emphasizes the importance of lethal temperature limits.

A small margin of safety exists between the optimum for growth and survival of a species. A 5°F. rise above optimum growth would result in increased mortality (Figure 1; Table D-5), increased deformities of fry, decreased growth,

increased incidence of disease, and avoidance of heated waters if given a choice. The net result would be a lower standing population of the desired species, and a change in species composition to one tolerant of warmer waters.

Consideration must be given to trout and other cold-water fishes that inhabit many headwater streams. As shown in Table D-5, temperatures above 61°F. present serious hazards to trout fry depending on the time of exposure. Because the few remaining trout waters in the Ohio River Basin may approach this temperature during the summer, it was recommended by the National Technical Advisory Committee that no thermal discharges be made to existing cold water fishery streams.

Table D-6 presents recommended seasonal maximum temperatures for the Ohio River to protect existing fisheries beyond the mixing zone. These data were selected to provide for a continued, sustained fishery in the Ohio River including the most critical recruitment phase. Recommended seasonal temperature criteria follow the natural climatic cycles for the Ohio River (Figure 2).

Table D-7 presents recommended temperature criteria for cold water fisheries such as exist in headwater streams in the Ohio Basin Region, especially in the Appalachia Region. To maintain a cold water fishery, many of these streams cannot tolerate a heat load except when ice is present.

Table D-8 summarizes the percentage of species that will be affected at various life history stages with the existing ORSANCO temperature criteria (Fourth Progress Report), the criteria proposed by the Ohio Basin Region, and the present thermal regiment of the Ohio River. Graphic illustration of these criteria is presented in Figure 2. The present ORSANCO criteria will not provide protection for the majority of fish species inhabiting the river. Temperatures lethal to 43 percent of the species, and that would interfere with reproduction of 64 percent of the species, would be allowed. The recommended Ohio Basin Region criteria are designed to prohibit additional water quality degradation, provide for a self-sustaining fishery, and permit judicious use of the river for cooling purposes.

Table D-1. Maximum temperatures (°F) for growth, reproduction, survival, and final preferendum of four species of fish. Parenthesis denotes estimates.

Species	Reproduction Spawning	Reproduction Egg	Growth	Activity	Final Preferendum Field	Final Preferendum Lab	Lethal Temperature 96-hr. TL_m	Lethal Temperature Acclimation
Northern Pike		64[1/]	70[1/]			(75)[3/]	79[1/]	64
Brook Trout	50[1/]	54[1/]	61[1/]	64[2/]	68[2/]	66[2/]	77[1/]	60
White Sucker		70[1/]	81[1/]		69[2/]	81[1/]	85[2/]	77
Largemouth Bass[2/]	75	81	86	84	82	90	(95)[4/]	86

1/ Unpublished data, NWQL
2/ Published literature
3/ Based on published data for muskellunge
4/ Based on 24-hour TL_m of 97°F

Table D-2. Maximum temperatures for reproduction of some Ohio River fishes and their observed spawning season. Parenthesis denotes estimates.

Species	Maximum Temperature (°F) for Reproduction Spawning	Egg Incubation	Spawning Season Time	Location
Largemouth Bass	75[2/]	80[2/]	Mid April-Mid May	Ky.[3/]
Smallmouth Bass	70[2/]	75[2/]	Mid April-Mid May	Ky.[3/]
White Bass	75[2/]	(75)[10/]	Mid March-April	Ark.[4/]
Sauger	60[3/ 8/]	(64)[11/]	Mid April-Mid May	Tenn.[3/]
Chann l Catfish	80[5/]	82[5/]	Mid May-June	Ark.[5/]
Emerald Shiner	76[6/]	80[6/]	Late May[2/]-July[6/]	Ohio[6/] Ill.[2/]
Freshwater Drum	72[7/]	78[7/]	May	Ala.[7/]
Golden Redhorse	64[4/]	(70)[12/]	Mid March-April	Ark.[4/]
Buffalo	70[7/]	(70)[12/]	Mid March-May	Ala.[7/]
White Sucker	62[1/]	70[1/]	April-May	Ill.[2/]
Fathead Minnow	79[9/]	79[9/]	April-Sept.	Ohio[9/]

1/ Unpublished data, NWQL, Duluth, Minnesota.
2/ Published Literature.
3/ Personal Communication, Gordon Hall, TVA.
4/ Personal Communication, Tom Duncan, South Central Reservoir Investigation, Fayetteville, Arkansas.
5/ Personal Communication, Kermit Sneed, Warmwater Fish Cultural Laboratories, Stuttgart, Arkansas.
6/ Flittner, G.A. 1964. Morphometry and life history of the emerald shiner, Notropis at herinoides Rafinesque. Ph.D. thesis, University Michigan, 208 p.
7/ Personal Communications, Bill Wren, TVA.
8/ Personal Communications, Gordy Priegel, Wisconsin Conservation Dept.
9/ Unpublished Data, NWQL, Newtown, Ohio.
10/ Estimated value from spawning observation.
11/ Based on unpublished data, NWQL, Duluth, Minnesota. Data based on Yellow Perch, a related species that spawn at the same time of the year.
12/ Based on white sucker data.

Table D-3. Optimum temperatures for activity and/or growth and the final preferred temperatures of some Ohio River fishes. Parenthesis denotes estimates.

Species	Optimum Temperature (°F) Activity - Growth	Final (or) Preferred Temperature Field - Lab
Largemouth Bass	84[1] - 86[1]	82[1] - 90[1]
Smallmouth Bass	86[1] - 84[1]	71[1] - 82[1]
White Bass	(86)[2]	
Sauger	(76)[4]	66[1] - (76)[4]
Channel Catfish	86[6]	
Emerald Shiner	(84)[5]	
Freshwater Drum	(83)[2]	72[1]
Golden Redhorse	(81)[7]	
Buffalo	(86)[2]	
White Sucker	81[3]	69[1] - 81[3]

1/ Published literature
2/ Based on data for channel catfish. Relationship established by the grouping of species by NTAC.
3/ Unpublished data, NWQL, Duluth, Minnesota.
4/ Based on published data on final preferred temperatures of yellow perch fry.
5/ Based on established relationship between reproduction and lethal temperatures.
6/ Personal communication, Kermit Sneed, Warmwater Fish Cultural Laboratories, Stuttgart, Arkansas.
7/ Based on white sucker data.

Table D-4. Lethal temperatures[1/] for some Ohio River fishes. Parenthesis denotes estimates.

Species	Acclimation Temperature (°F)	Lethal Temperature (°F) Upper	Lower
Largemouth Bass	86	97	53
	68	90	42
Smallmouth Bass	Summer	>90	--
Sauger (Yellow Perch)	(77)	(96)	(39)
	(41)	(70)	(32)
Channel Catfish	77	92	43
	59	87	32
Emerald Shiner	77	87	46
	41	74	32
White Sucker	77	85	43
	41	79	32
Fathead Minnow	86	92	51
	50	83	32

1/ Hart (1947). Trans. Royal Soc. Can. 3rd Series, Sec. 5, Vol. XLI.
Hart (1952). Publ. Ont. Fish. Res. Lab., No. LXXII. Univ. Toronto press.

Table D-5. Relationship between lethal temperatures and optimum temperatures for growth of brook trout fry.

Item	Temperature (°F)
1-Hour TL_m	82[1/]
24-Hour TL_m	79[2/]
7-Day TL_m	76[2/]
2-Month Safe (no increase in mortality rate)	61[2/]
Optimum growth	61[2/]

1/ Fry, F.E.J., et. al., 1946. Lethal temperature relations for a sample of young speckled trout, Salvelinus fontinalis. Univ. Toronto Stud. Biol. Ser. 54, Pub. Ont. Fish Res. Lab. 66, pp. 1-35.

2/ Unpublished data, NWQL, Duluth, Minnesota

Table D-6. Recommended Temperature Criteria For The Ohio River

I have critically examined the OBR temperature criteria for the Ohio River based on a 5-year average monthly temperature near Cincinnati and have found it to be adequate for warm-water fish habitats on the average. However, at warm stations in warm seasons and through warming of the "ambient" river temperature, reproduction of most Ohio River fishes would be in jeopardy in areas affected. It is my belief (and Dr. Mount's) that seasonal maximum temperatures should be established in place of or in addition to degree rise above ambient. In order to safeguard growth, reproduction, and survival of important Ohio River fishes, the stream temperature should not exceed the following temperatures at anytime or place beyond the defined mixing zone:

	Daily Mean (°F)	Hourly Max. (°F)
Dec. - Feb.	48	55
Early March	50	56
Late March	52	58
Early April	55	60
Late April	58	62
Early May	62	64
Late May	68	72
Early June	75	79
Late June	78	82
July - Sept.	82	86
Oct.	75	82
Nov.	65	72

If a five degree rise above ambient is still desired, I can see nothing wrong with a 10°-15°F. degree rise as long as the above maximums are not exceeded.

Table D-7. Recommended Temperature Criteria for Cold-water Fisheries

Recently completed studies on brook trout at the NWQL Laboratory suggest revisions of the criteria for cold-water trout streams where natural reproduction is to occur.

	Daily Mean (°F)	Hourly Maximum (°F)
October - April	50	55
September and May Transition Period	58	62
June - August	66	70

Table D-8. Percentage of Ohio River fishes affected by various criteria proposals

Item	ORSANCO	OBR	Ohio River[1]
	Early spring spawners not susceptible		
Suboptimal[2] Spawning	7/11 (64%)	0/11 (0%)	0/11 (0%)
Suboptimal[3] Growth	10/10 (100%)	1/10 (10%)	1/10 (10%)
Summer Avoidance Response (Field)	5/5 (100%)	4/5 (80%)	4/5 (80%)
Summer Avoidance Response (Lab)	3/4 (75%)	1/4 (25%)	1/4 (25%)
Lethal Temperature (Summer)	3/7 (43%)	0/7 (0%)	0/7 (0%)
Lethal Temperature (Winter)	0/6 (0%)	0/6 (0%)	0/6 (0%)

1/ Based on a five-year (1963-1968) grand average of maximum and minimum daily average temperatures for each month in the Ohio River, Cincinnati.

2/ More than 50 percent of the spawning season above safe temperatures for reproduction.

3/ Above optimum temperatures for growth and activity. May-Sept. (ORSANCO); July-Sept. (OBR); periodically - July-August (Ohio River).

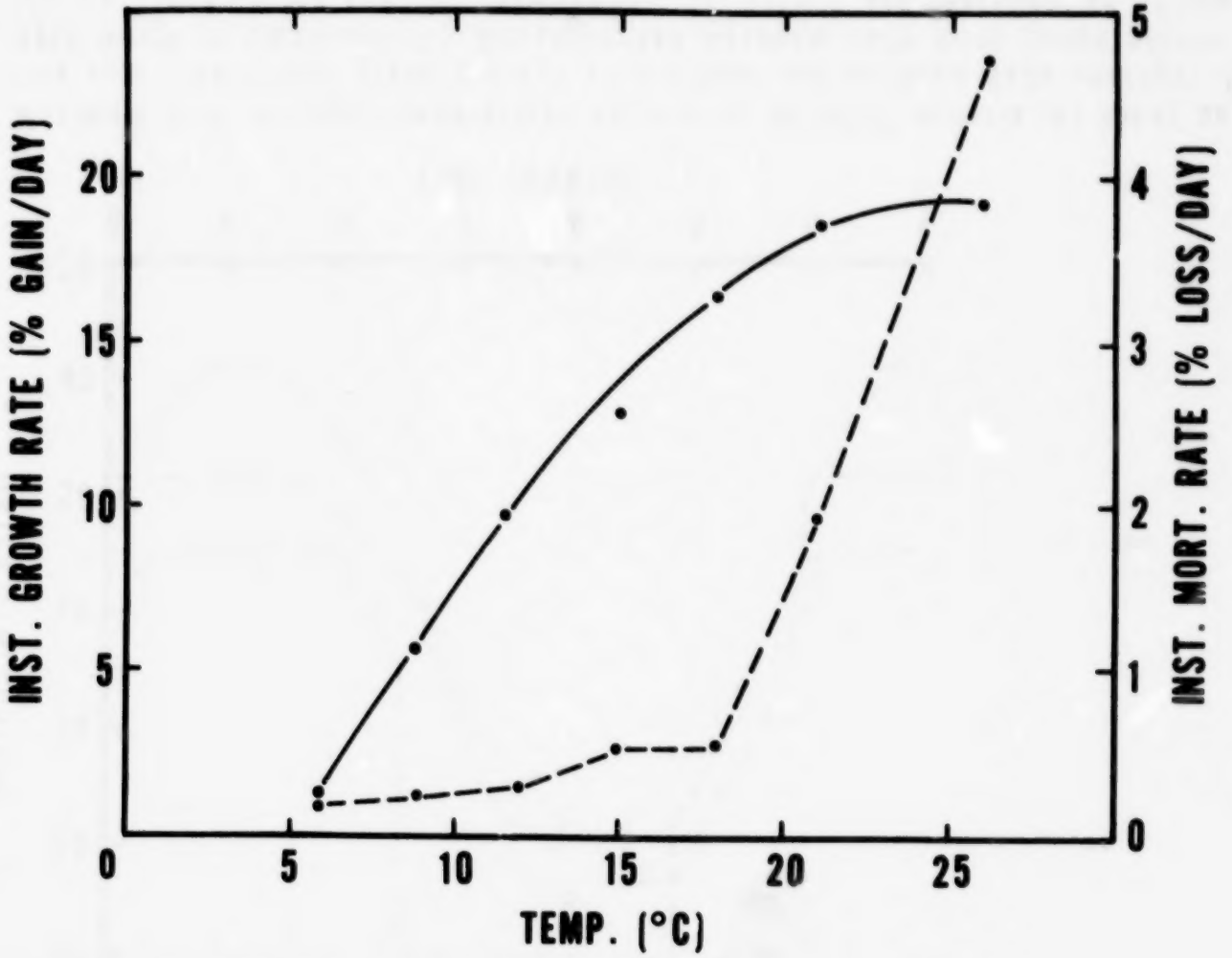

FIGURE 1. Effect of temperature on the instanteous growth rate (solid line) and mortality rate (dashed line) of northern pike in their first 3 weeks of life.

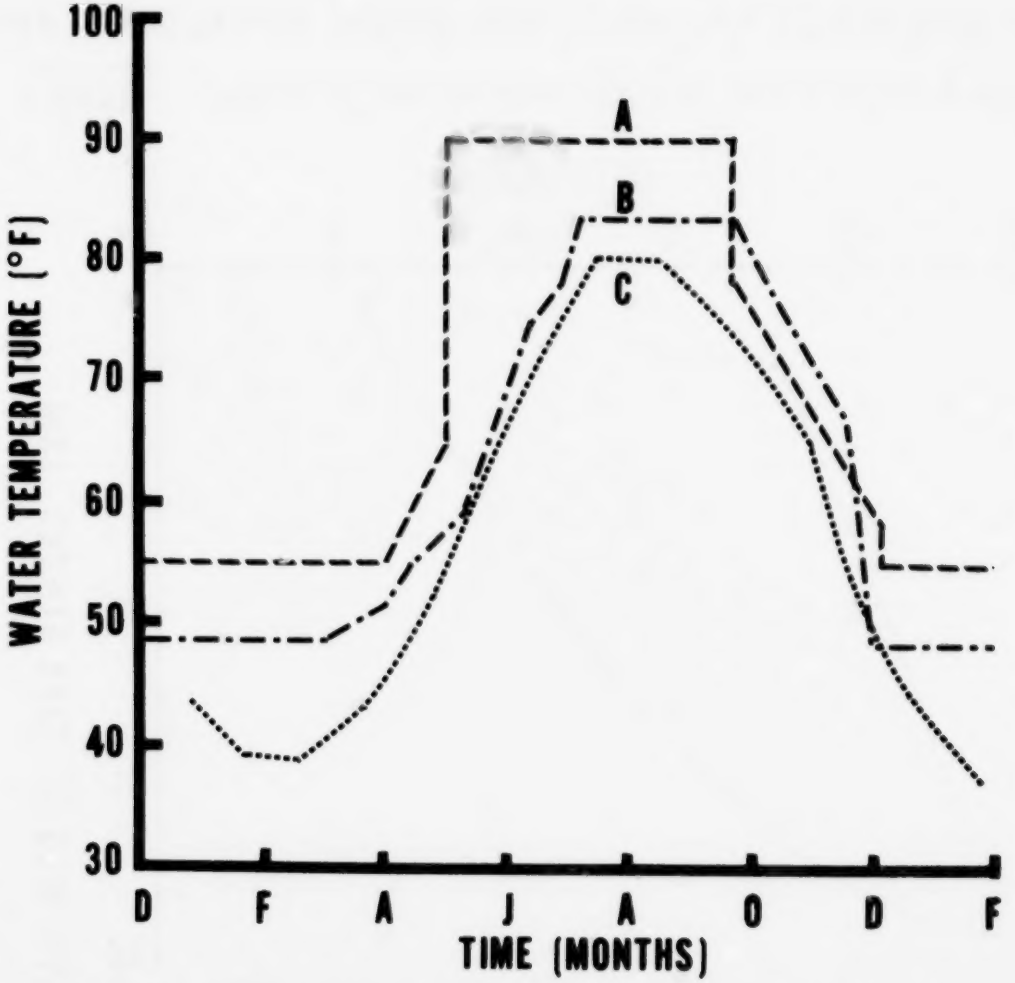

FIGURE 2. Maximum daily average temperatures allowed by ORSANCO criteria (A) based en a five year (1963-1968) grand average of maximum and minimum daily averages for each month at Cincinnati (C). Recommended maximum daily mean temperatures (B) are based on the specific requirements for growth and reproduction of important Ohio River fishes.

DISSOLVED OXYGEN CONDITIONS OF THE OHIO RIVER

K.O. Schwab and B.R. Sacks

The available data on dissolved oxygen in the Ohio River was evaluated with particular emphasis on dissolved oxygen fluctuations at times when dissolved oxygen was in a range of 4.0 to 6.0 mg/l. It was concluded that with minimum hourly dissolved oxygen values of 4 mg/l, average daily dissolved oxygen values may be as low as 4.1 mg/l. Further, with daily average values of 5 mg/l, minimums may be below 4 mg/l at times. This evaluation is further detailed in Part II of this section.

PART I - PRESENT CONDITIONS

The dissolved oxygen conditions in the Ohio River were presented in attachments 4 and 5 of the Engineering Committee Agenda. Exhibit E-1 is an extraction from attachment 5 of this agenda. This Exhibit is largely self-explanatory and shows that, except at Cincinnati, the minimum of 4 mg/l was not met a significant part of the time during 1967. At Cincinnati, the minimum of 4 mg/l was met about 97% of the time during the months of June through October.

The FWPCA Markland Pool Report is the basis for the following conclusions, which subject to local variables, are probably applicable to considerable portions of the Ohio River:

1. During the time of field studies, the maximum diurnal fluctuation was 2 mg/l with most fluctuations below 1 mg/l. Fluctuations were due more to diurnal fluctuations in waste loading than to photosynthesis.

2. During the 1963 Markland Pool study, dissolved oxygen values at the surface were from 0.1 to 0.3 mg/l higher at the surface than that found at a depth of 18 feet.

3. Lateral dispersion was judged complete in 5 miles. Pre-impoundment dissolved oxygen values were 0.5 to 1.0 mg/l greater on the Kentucky shore below the Mill Creek outfall than on the Ohio shore. Post-impoundment conditions showed that dissolved oxygen values were only 0.1 mg/l greater on the Kentucky shore.

The above observations lead to the conclusions that dissolved oxygen concentrations are relatively uniform across a cross-section under conditions presently encountered on the Ohio River.

PART II - INTERPRETATIVE EVALUATIONS

This part relates the present ORSANCO criteria for dissolved oxygen (D.O.) with the proposed amended criteria in the Ohio River.

The present criteria sets the dissolved oxygen at "not less than 5 mg/l during at least 16 hours of any 24-hour period, nor less than 3.0 mg/l at any time." This statement requires sampling over the 24-hour period. The minimum daily average dissolved oxygen would be 4.33 mg/l based on this criteria.

The proposed amendments will be compared next using Ohio River dissolved oxygen data collected and analyzed by ORSANCO. The two amendments are "The D.O. concentration shall average 5.0 mg/l per calendar day and shall not be less than 4.0 mg/l at any time or any place," and "the D.O.concentration shall not be less than 4.0 mg/l at any time or any place."

The data for dissolved oxygen was examined for the station at Huntington, West Virginia (mi. 304.2) for the months of June to October, 1963 to 1968, and for the station at Miami Fort, Ohio (mi. 490.3) for the months of June to October, 1965 to 1968. For 18% of the time, the difference between the minimum hourly and the daily average dissolved oxygen values was 0.10 mg/l or less for the same calendar day. Forth-six percent of the time the difference was 0.20 mg/l or less.

This shows that if only a minimum dissolved oxygen of 4.0 mg/l would be specified, the minimum daily average will be practically the same. The above analysis was performed on those data where the minimum was in the range of 3.0 - 5.0 mg/l in order to be close to the proposed conditions. The above percentages would have been higher if the concentrations below 2 mg/l would have been included.

Three percent of the time at Huntington and 14% of the time at Miami Fort, the difference between the daily average and the minimum hourly values was greater than 1 mg/l. This indicates that a minimum daily average of 5.0 mg/l would permit minimum hourly values below 4.0 mg/l.

The above analysis was performed on those data where the average was in the range 4.0 to 6.0 mg/l in order to be close to the proposed conditions. The maximum difference between the daily average and minimum hourly value was 3.50 mg/l.

The percents mentioned previously vary for each station but indicate the trends of the data.

In summary, the FWPCA recommendation that "The D.O. concentration shall average 5.0 mg/l per calendar day and shall not be less than 4.0 mg/l at any time or any place", allows for a minimum daily average of 5.0 mg/l D.O. with no single hourly value below 4.0 mg/l. However, the ORSANCO Aquatic Life Advisory Committee recommendation of "The D.O. concentration shall not be less than 4.0 mg/l at any time or any place", allows for minimum hourly D.O. concentrations of 4.0 mg/l with a minimum daily concentration of 4.0 mg/l. The average monthly concentration will probably be greater than 5.0 mg/l. In both cases, the D.O. concentration is limited so that no single hourly value is below 4.0 mg/l.

EXHIBIT E-1

DISSOLVED OXYGEN CONDITIONS
IN THE OHIO RIVER
JUNE THROUGH OCTOBER 1967

Percent of Days Minimum D.O. Value Less than Indicated Value

D.O. mg/l	South Heights (16.0)	Stratton (55.0)	Huntington (304.2)	Cincinnati (462.8)	Miami Fort (490.3)	Louisville (600.6)	Cane Run (616.8)
2.0	9.6	5.7	8.1		10.9	12.1	20.1
3.0	16.8	9.8	32.4	0.8	24.5	21.5	40.3
3.5	20.0	12.2	45.9	1.6	33.6	28.2	52.3
4.0	23.2	13.8	54.7	3.1	43.6	38.2	65.1
4.5	27.2	14.6	66.9	7.1	56.4	49.7	76.5
5.0	33.6	14.6	73.0	10.2	63.6	64.4	83.9
6.0	54.4	24.4	88.5	39.4	81.8	83.2	87.2
7.0	68.0	32.5	96.6	67.7	94.5	98.0	89.9

Extracted from Attachment No. 5 - Engineering Committee Agenda

INDIVIDUAL STATES ADOPTED DISSOLVED OXYGEN CRITERIA

B. Wright

Dissolved Oxygen Criteria for Aquatic Life of
ORSANCO States

STATE	CRITERIA	APPROVED
Illinois	Not less than 5.0 mg/l during at least 16 hours of any 24-hour period, nor less than 4.0 mg/l at any time.	Pending approval
Indiana	Warm water fish habitat: Not less than 5.0 mg/l during at least 16 hours of any 24-hour period, nor less than 3.0 mg.l at any time. Cold water fish habitat: Not less than 6.0 mg/l as a daily average value, nor less than 4.0 mg/l at any time.	July 8, 1967 *
Kentucky	Not less than 5.0 mg/l during at least 16 hours of any 24-hour period, nor less than 3.0 mg/l at any time.	Excepted from approval-March 20, 1969
New York	For trout waters, not less than 5.0 ppm; for non-trout waters, not less than 4.0 ppm.	August 7, 1967 *
Ohio	Not less than 5.0 mg/l during at least 16 hours of any 24-hour period, nor less than 3.0 mg/l at any time.	Excepted from approval - March 4, 1968

* Standards are to be reviewed for consistency with present criteria recommendations

Pennsylvania	Warm water fish habitat: b_2 - Minimum daily average 5.0 mg/l; no value less than 4.0 mg/l. Cold water fish habitat: b_1 - Minimum daily average 6.0 mg/l; no value less than 5.0 mg/l.	May 21, 1968
Virginia	Warm water fish habitat: Minimum of 4.0 mg/l; Cold water fish habitat: Minimum of 5.0 mg/l.	Excepted from approval - January 17, 1969
West Virginia	Not less than 5.0 mg/l during at least 16 hours of any 24-hour period, nor less than 3.0 mg/l at any time. After suitable abatement is affected or five years from date of standards - not less than 5.0 mg/l at any time.	May 21, 1968

Productivity and Seasonal Variations Related

to Aquatic Life Dissolved Oxygen Requirements

W. A. Brungs

One of the most important detrimental conditions in aquatic environments is low dissolved oxygen concentrations. The quantity of biological and chemical oxygen demanding wastes in this environment is excessive in many locations. Because of the biological importance of reduced dissolved oxygen levels and the frequency of its occurrence, one would expect much experimental data on this subject. The technological problems involved during dissolved oxygen experimentation is the principal cause of the paucity of good experimental data.

The most useful manuscript (1) available resulted from five years of observations at 982 locations around the country by Dr. Ellis during 1930-1935. He investigated aquatic life populations and related observed environmental conditions to the well-balanced warmwater fish populations he found. Exhibit G-1 from this manuscript summarizes the observed dissolved oxygen concentrations observed during the months of June to September at the 372 stations where he found good warmwater fish populations. He states that "it may be seen that during the warm season the waters at 96 percent of the good fish faunae stations carried 5 ppm or more dissolved oxygen, and that in all of the 5,809 cases, good, mixed fish faunae were not found in waters carrying less than 4 ppm. dissolved oxygen." The 5,809 cases he refers to are the number of dissolved oxygen determinations made during his study. Data more pertinent to us are summarized in Exhibit G-2, also from Ellis.

It contains data from 37 stations in the Ohio River. The solid black graph presents all oxygen data regardless of presence or absence of fish at sampling stations. The stippled graph is a composite of dissolved oxygen values for all stations at which good mixed fish faunae were found. His observations in the Ohio River led to the same generalization he made for the country as a whole.

More recent information is available from the Field Investigations Branch (2), Federal Water Pollution Control Administration, Cincinnati, Ohio. Their survey of the Great Miami River in 1968, has resulted in the same observations and conclusions of Ellis, thirty years earlier. One conclusion of this recent survey was "in the Great Miami River, balanced fish populations require minimum dissolved oxygen concentrations in excess of 4.0 mg/l."

Fortunately the available data from laboratory research provide valuable insight into the resolution of a dissolved oxygen criterion for the Ohio River. In a summary of dissolved oxygen requirements of fishes by Doudoroff and Warren (3) they include data (Exhibit G-3) that under the described test conditions any reduction in dissolved oxygen concentrations below saturation (8.2 mg/l) resulted in decreased growth of juvenile largemouth bass.

Recent, and as yet unpublished data (4), shown in Exhibit G-4, were obtained with a local fish species and water similar to that in the Ohio River. Fry survival was significantly reduced at 4.0 mg/l dissolved oxygen, and again growth was reduced at concentrations below 7.9 mg/l.

All these field and laboratory investigations were concerned with only reduced dissolved oxygen levels. Overlooked, in most considerations of reduced oxygen concentrations, is the production of many other substances, but especially ammonia and hydrogen sulfide, both very toxic to fish at levels as low as 20 µg/l. An absolute minimum criterion for dissolved oxygen cannot be considered safe for aquatic life because such a condition usually occurs unnaturally in the presence of organic wastes and materials formed by degradation of these wastes. These cause additional stress on aquatic life and, together with minimum safe dissolved oxygen concentrations (safe in the absence of other stresses), create an unsatisfactory aquatic environment.

References

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2. Manuscript

   Great Miami River Survey. Field Investigations Branch,

   Federal Water Pollution Control Administration, U.S. Dept. of

   the Interior, Cincinnati, Ohio. (1968).

3. Drudoroff, Peter and Charles E. Warren

   Dissolved oxygen requirements of fishes.

   Biological Problems in Water Pollution, 3rd Seminar,

   U. S. Dept. of Health, Education, and Welfare, PHS Pub. No. 999-WP-25

   (1965).

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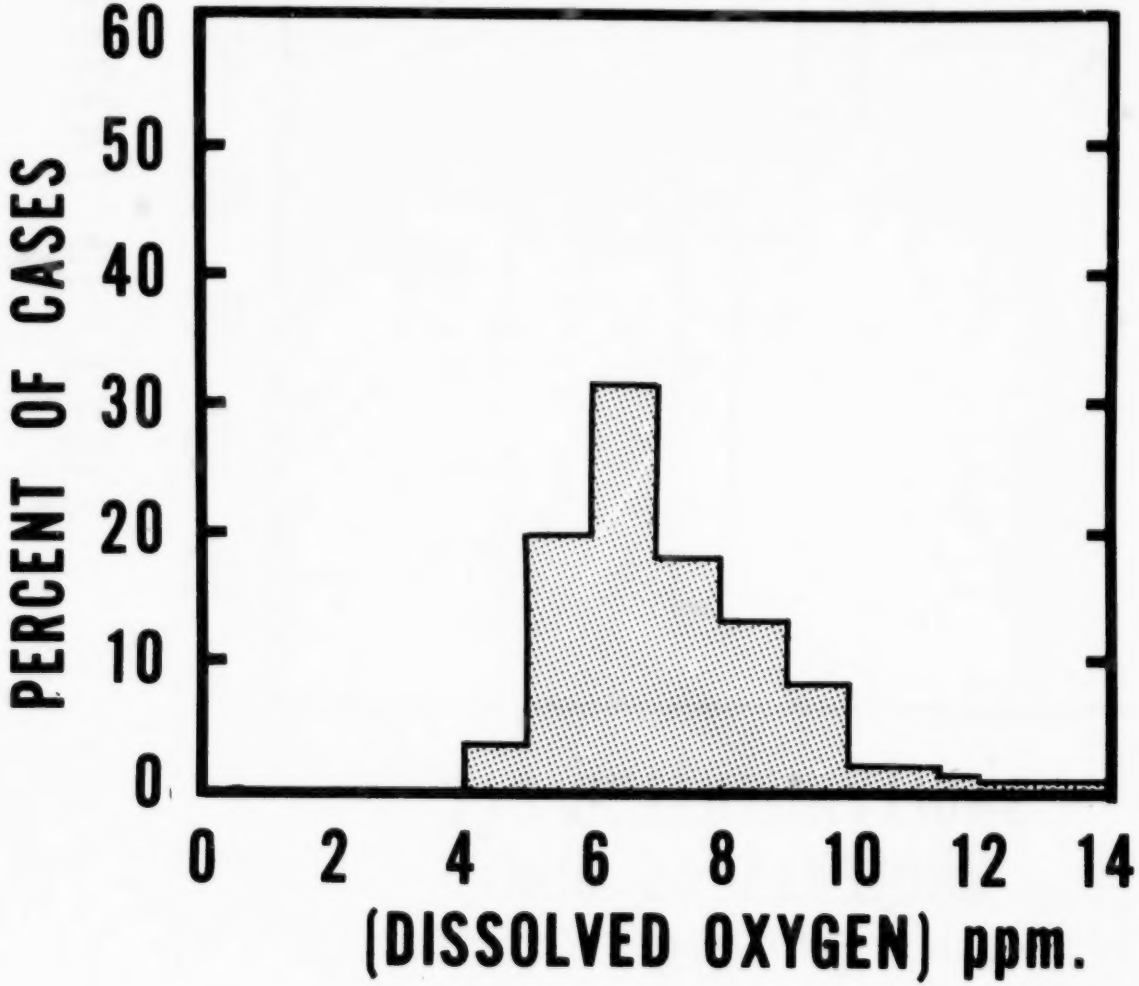
   Effect of reduced dissolved oxygen concentrations on reproduction

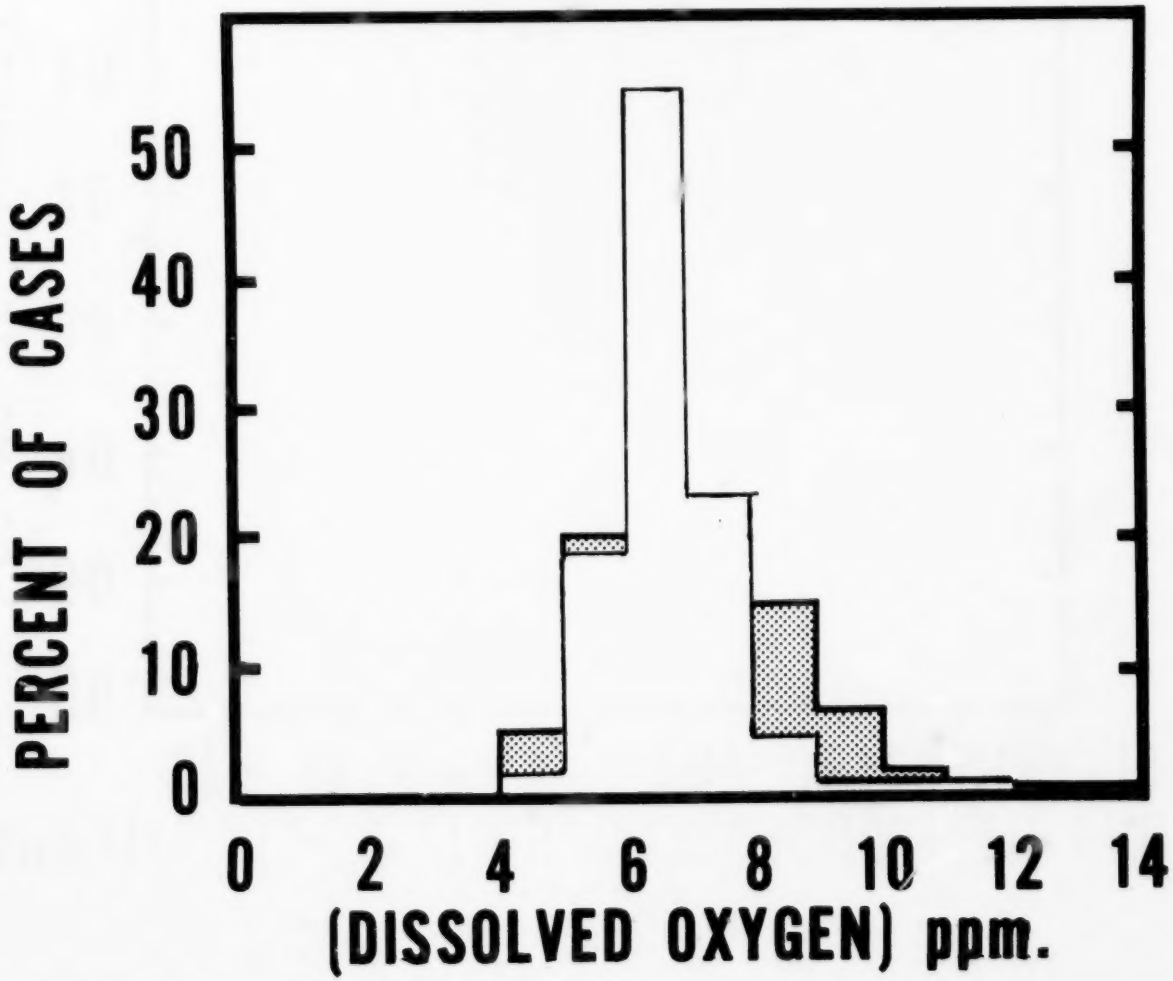
   and growth of the fathead minnow. (Manuscript).

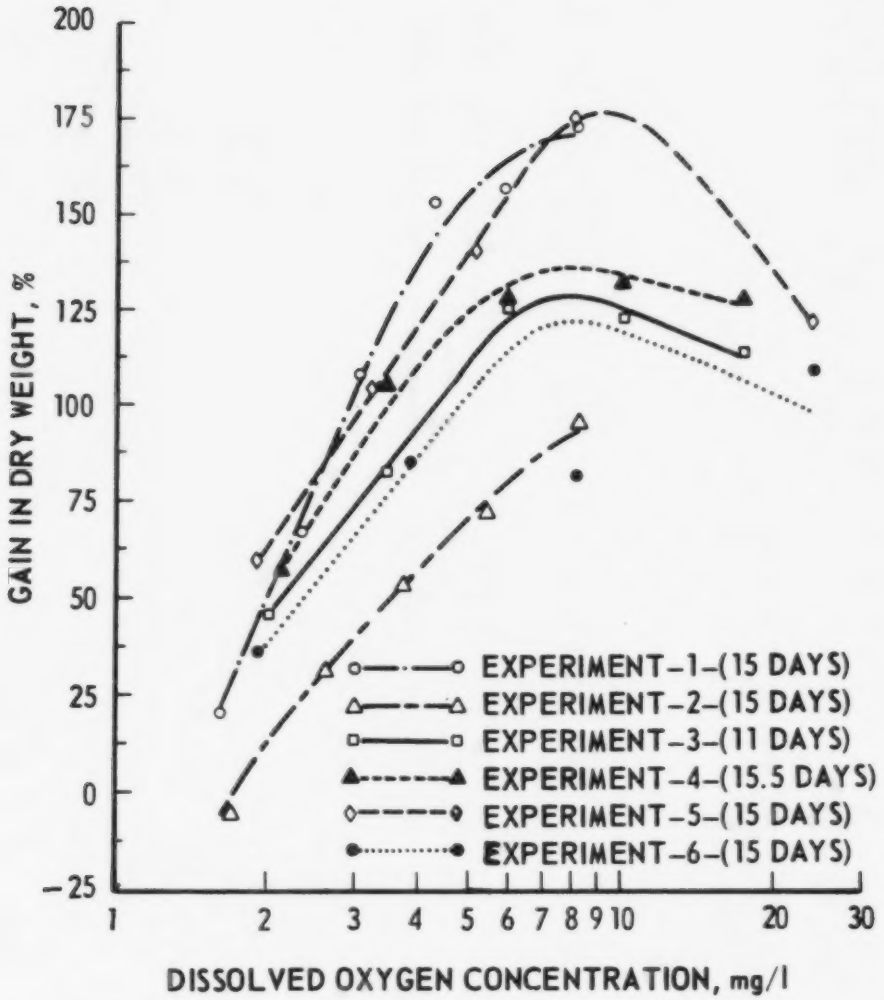
G-1

COMPOSITE, LOCALITIES WITH GOOD FISH FAUNA
372 STATIONS, 1,297 DETERMINATIONS



G-2
OHIO 37 STATIONS, 379 DETERMINATIONS





G-3 Percent gains in dry weight of juvenile largemouth bass kept on an unrestricted diet of earthworms for 11 to 15.5 days at 26°C, in relation to dissolved oxygen concentrations. (After Stewart, 1962.)

SURVIVAL & GROWTH OF FATHEAD MINNOW FRY SPAWNED AT EXPERIMENTAL DISSOLVED OXYGEN CONCENTRATIONS

DISSOLVED OXYGEN, mg/l	SURVIVAL, percent	MEAN LENGTH AFTER 30 DAYS, mm
2.0	0	—
3.0	6	9.2
4.0	25	9.2
5.0	66	9.7
7.9	50	11.7

DATA FROM THE NEWTOWN FISH TOXICOLOGY LABORATORY

PRESENT pH CONDITIONS OF THE OHIO RIVER

K.O. Schwab

Mine drainage is recognized as a major problem which contributes to a lower pH range in the Upper Ohio River.

The percentage of time the pH values fell within the preferred range of 6.5 to 8.5 in 1967 for the Ohio River is presented in Exhibit H-1. This information is extracted from the 1968 Annual Report of ORSANCO. All values outside the preferred range were below a 6.5 value at all stations except Cane Run. The values not in the preferred range, and above 8.5, were observed at Cane Run.

Mine drainage is believed to be the major but not sole cause of low pH values at South Heights and Stratton. At Cane Run, high pH values could be caused by a combination of tributary inflow (which at times is above 8.5), industrial discharges, and photosynthetic activity. Photosynthetic activity is not, however, believed to be a significant factor for the Lower Ohio River, based on existing studies. With a determined abatement program for mine drainage and other sources, it appears that a range of 6.5 to 8.5 is both reasonable and attainable.

EXTENT TO WHICH PERCENT OF DAILY-AVERAGE pH VALUES WERE WITHIN 6.5 TO 8.5 FOR THE YEAR 1967.

STATION	PERCENT
SOUTH HEIGHTS	56.5
STRATTON	62.1
HUNTINGTON	89.6
CINCINNATI	99.7
MIAMI FORT	99.7
LOUISVILLE	96.8
CANE RUN	93.0

SOURCE: ORSANCO 1968 ANNUAL REPORT

INDIVIDUAL STATES ADOPTED pH CRITERIA

B. Wright

pH Criteria of ORSANCO States
For Aquatic Life

STATE	CRITERIA	APPROVED
Illinois	No values below 6.0 nor above 9.0, and daily average (or median) values preferably between 6.5 and 8.5.	Pending approval
Indiana	Warm water fish habitat: No values below 6.0 nor above 9.0 and daily average (or median) values preferably between 6.5 and 8.5. Cold water fish habitat: Not less than 6.5 nor greater than 8.5 at any time.	July 18, 1967*
Kentucky	No values below 5.0 nor above 9.0 and preferably between 6.5 and 8.5.	Excepted from approval - March 20, 1969
New York	Range between 6.5 and 8.5.	August 7, 1967*
Ohio	No value below 5.0 nor above 9.0, and daily average (or median) values preferably between 6.5 and 8.5. Where applicable, the treatment requirements shall be such as to maintain the pH of the receiving waters in the preferred range of 6.5 to 8.5.	March 4, 1968
Pennsylvania	a_1 - Not less than 6.0; not to exceed 8.5.	May 21, 1968
Virginia	6.0 - 9.0.	January 17, 1969

* Standards are to be reviewed for consistency with present criteria recommendations

STATE	CRITERIA	APPROVAL
West Virginia	No values below 5.5 nor above 9.0, and daily average (or median) values preferably between 6.5 and 8.5. (After suitable abatement is affected or five years from the date of the standards - values normal for the waters in the area in question, however, generally held between 6 and 8.5.)	May 21, 1968

Aquatic Life pH Requirements

W. A. Brungs

The establishment of aquatic life criteria for a single watershed such as that of the Ohio River, is, fortunately, less difficult than establishing criteria for the United States. The environment, both physical and biological, is less complicated in the former. Much information on the distribution of well-rounded, warmwater fish populations is available for the Ohio River watershed.

Laboratory-derived criteria always require substantiation of some sort by field experimentation and/or observation. This can be especially true for pH. It is very difficult to separate the effects of pH on the aquatic environment from other variables associated with pH such as carbon dioxide and alkalinity.

The efforts of Ellis (1) in his five-year study of the distribution of warmwater fishes within the continental United States as related to pollution have provided a classic manuscript. His sampling represented a total of 1,125 localities. This exhibit (J-1) was constructed from the data from 409 localities where he found good, mixed populations of fish. This composite covers a range between pH 6.3 and pH 9.0. Of most concern is the fact that 97 percent of the cases were between pH 6.7 and pH 8.6. This range was basically the same for unpolluted waters in general. The next exhibit (J-2) is a composite of his Ohio River data for 37 stations. As he indicated, "the effects of acid pollution are evident in the Ohio River." The solid black graph presents all

pH data regardless of presence or absence of fish at all stations. The stippled graph is a composite of pH values for all stations at which good mixed fish faunae were found and nearly all points were within the range of pH 6.7 to pH 8.6.

Fish culturists have long noted that alkaline ponds and streams are much more productive than acid ones; reduction in pH results in a decreasing production rate. High pH values have been investigated less than low ones but a pH over 8.5 should be suspected as being of a pollutional nature, either from a discharge or from excessive algal growth. This statement is especially true of the Ohio River system where highly alkaline natural waters are rare.

The decrease in production caused by low pH has been established also by laboratory research (2). This exhibit (J-3) includes data that indicate a decrease in production of the fathead minnow, below pH 7.6. There was a highly significant production decrease at pH 6.8 and egg hatchability at pH 6.0. These data were obtained at the Newtown Fish Toxicology Laboratory using water similar to that in the Ohio River.

Exhibit J-4 includes several pH levels between 6.0 and 6.5 that have experimentally killed 50 percent of the test organisms in 96 hours (3, 4). Each of these organisms is known to be utilized as food by important species of fish.

In summary, the determination of a pH criterion for aquatic life must consider several important factors such as related changes in carbon dioxide and alkalinity, effects on fish production, and the location of the area for which the criterion is to be recommended.

A specific instance of the latter would be that a national criterion for pH (5,6) must consider softer, and usually more acid, natural waters. Since these waters are not typical of the Ohio River watershed they need not be considered and the pH criterion for the Ohio River should consequently be more restrictive.

Another extremely important, and often overlooked, consideration that is true for discussions of all criteria is that we cannot develop absolute marginal criteria and assume that the aquatic life will be desirable. When several conditions together with pH are marginal at the same time the additional stresses will be more than a well-balanced warmwater fish population can withstand.

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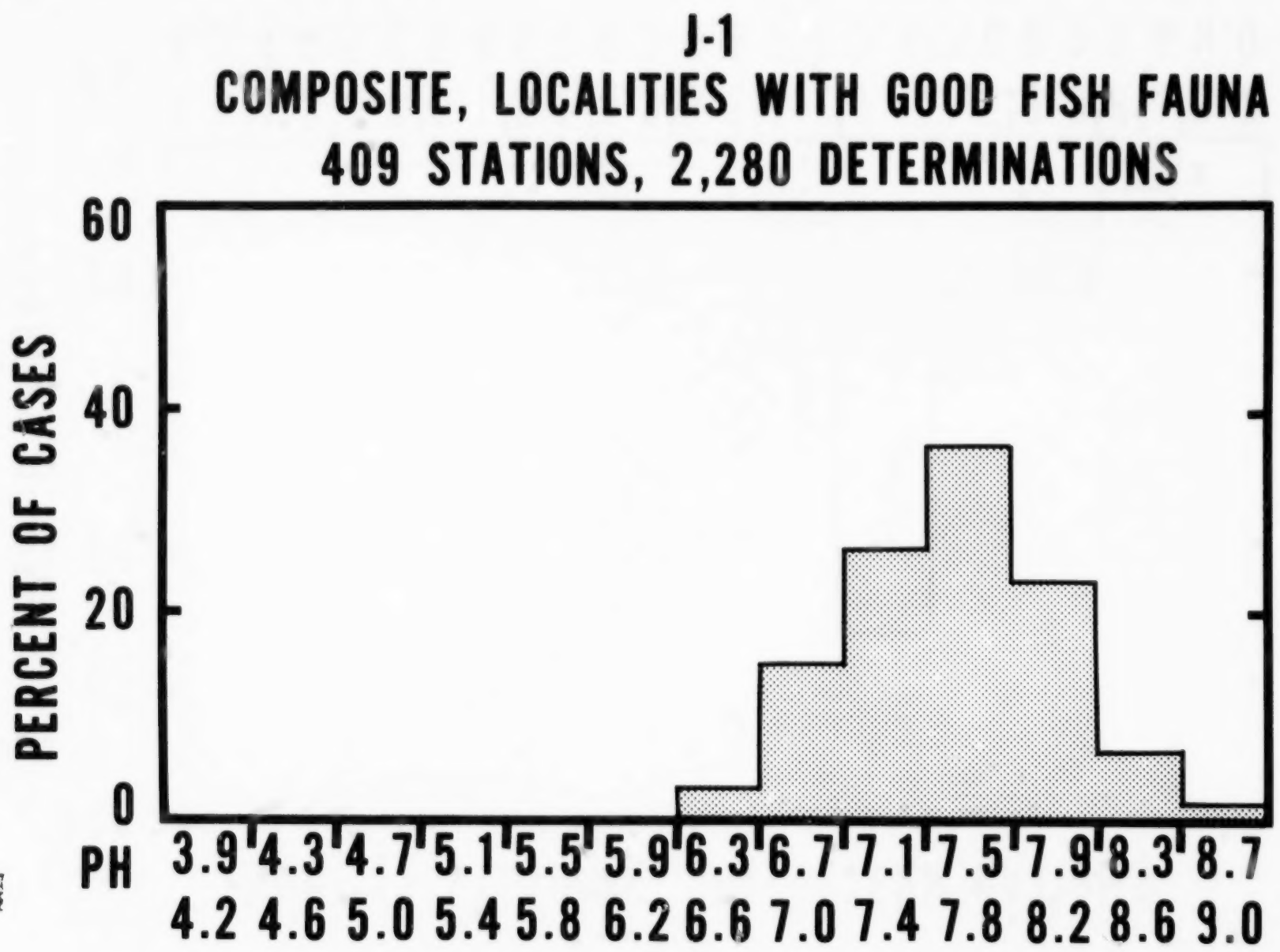
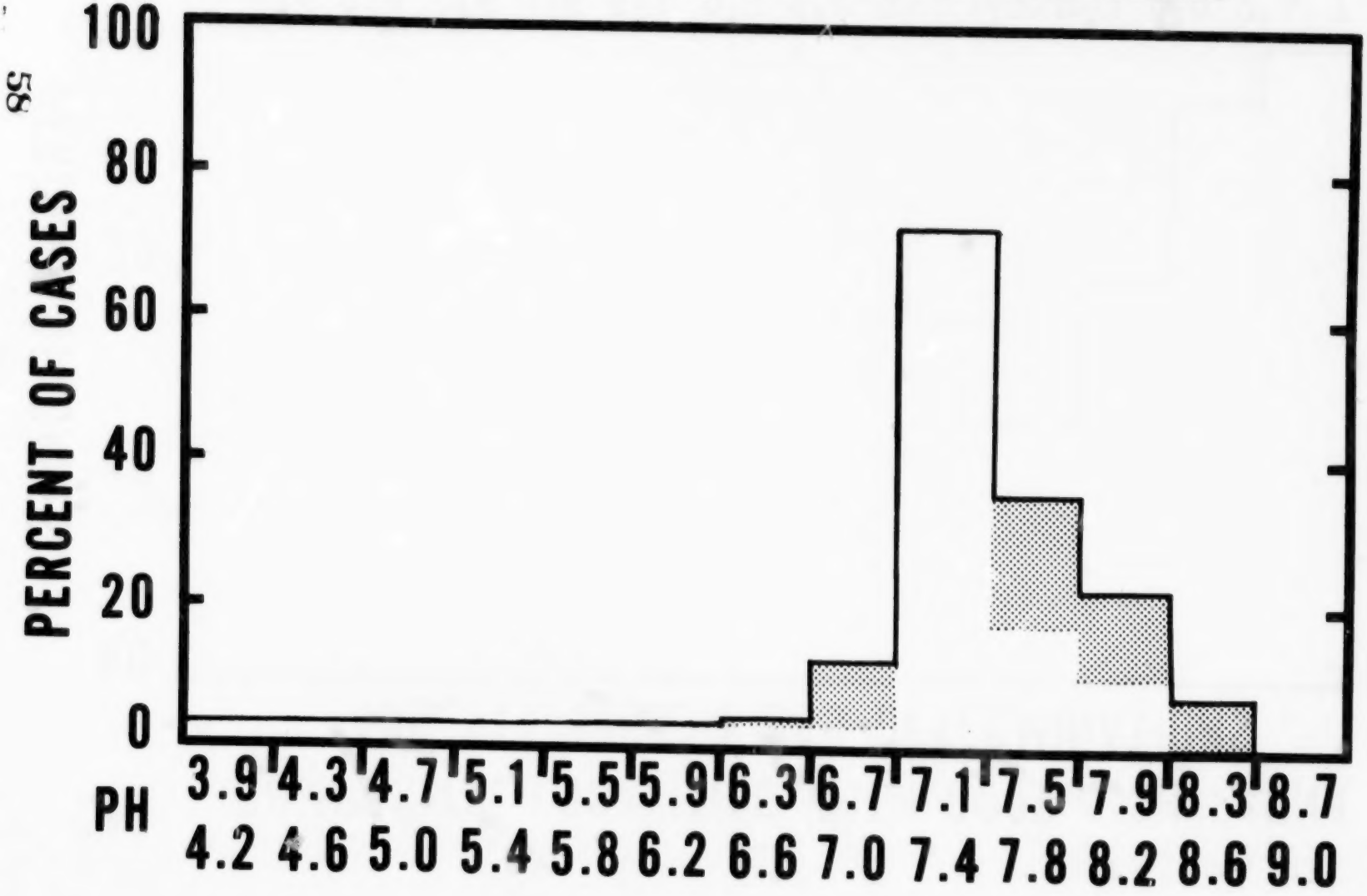

J-1
COMPOSITE, LOCALITIES WITH GOOD FISH FAUNA
409 STATIONS, 2,280 DETERMINATIONS
PERCENT OF CASES
60
40
20
0
PH
3.9 4.3 4.7 5.1 5.5 5.9 6.3 6.7 7.1 7.5 7.9 8.3 8.7
4.2 4.6 5.0 5.4 5.8 6.2 6.6 7.0 7.4 7.8 8.2 8.6 9.0

J-2

OHIO 37 STATIONS, 291 DETERMINATIONS



SPAWNING & EGG HATCHABILITY OF FATHEAD MINNOWS AT EXPERIMENTAL pH LEVELS

pH	EGGS PRODUCED/ FEMALE	EGG HATCHABILITY, PERCENT
5.4	0	—
6.0	110	43
6.8	240	82
7.6	1750	75

DATA FROM THE NEWTOWN FISH TOXICOLOGY LABORATORY

SOME pH LEVELS LETHAL TO FISH FOOD ORGANISMS

ORGANISM	96-HR. TL $\bar{m}$
SCUD (GAMMARUS)	5.6 (ADULT) 5.8-6.1 (NEWBORN YOUNG)
MAYFLY (RHITHROGENA)	6.4 (MATURE NYMPH)
MAYFLY (HEPTAGENIA)	6.2

DATA FROM THE NATIONAL WATER QUALITY LABORATORY
AND DR. ARDEN GAUFIN, UNIV. OF MONTANA

J-4

Implementation Plan Compliance for the Ohio River

R. S. Burd

We anticipate that each State sharing the Ohio River will press forward with whatever actions are necessary to assure compliance with the time schedules identified in the water quality standards adopted and approved for that State. For example, we expect dischargers located in Ohio to comply with schedules spelled out in the approved Ohio standards, not the latest date identified in some other State standard.

While the Kentucky water quality standards have been approved as Federal standards, in accordance with the Federal Water Pollution Control Act, it is important to note that one condition of the approval is that a detailed implementation plan be submitted to the Department of the Interior by July 1969. Consistency in the water quality standards of States sharing a river basin is essential. Hopefully, the Kentucky time schedules, when received, will be consistent with neighboring States for at least the major waste sources. ORSANCO appears to be a logical vehicle to encourage consistency in standards among member States.

PRESENT BACTERIOLOGICAL CONDITIONS OF THE OHIO RIVER

J. H. Adams, Jr.

The total coliform group is the classical indicator of fecal pollution. As defined in "Standard Methods for the Examination of Water and Waste Water" (12th ed.): "The coliform group includes all of the aerobic and facultative anaerobic, gram-negative, nonsporeforming rod shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C."

Coliforms are always present in the intestines of humans and other warm-blooded animals, and are eliminated in large numbers in fecal wastes.

Unfortunately, some strains included in the total coliform group have a wide distribution in the environment but are not common in fecal material. These organisms are well adapted and able to multiply in the environment as well as in the intestine of warm-blooded animals.

The fecal coliform component of the total coliform group is of relatively infrequent occurrence in the environment, except in association with fecal pollution. They generally do not multiply outside the intestines of warm-blooded animals.

Looking at bacteriological data gathered in 1963 on the Ohio River from Cincinnati to Markland Dam, Exhibit L-1, total coliform, fecal coliform ratios are as follows:

Station 472.4	from	5:1 to	230:1 (above Millcreek outfall)
Station 475.1	from	9:1 to	16:1 (below Millcreek outfall)
Station 503.3	from	16:1 to	23:1 (below Laughery Island, Ky.)
Station 531.2	from	3:1 to	7:1 (above Markland Dam)

Total coliform, fecal coliform ratios were computed from bacteriological data gathered from a pollution study conducted in 1968 from Owensboro, Kentucky to Evansville, Indiana, Exhibit L-2.

Total coliform, fecal coliform ratios were:

Above Owensboro, Ky.	280:1 to 400:1
Below Owensboro, Ky.	29:1 to 42:1
Newburgh, Ind.	35:1 to 40:1
Evansville, Ind.	115:1 to 1,300:1

Ratios were also computed from bacteriological data collected from pollution surveillance stations in 1968, Exhibit L-3.

Total coliform, fecal coliform ratios were:

Pa.-W. Va. State Line	21:1 to 30:1
Wheeling	15:1 to 81:1
Cincinnati	13:1 to 19:1
Miami Fort	4:1 to 8:1
Evansville	17:1 to 21:1

The wide differences in ratio indicate that the total coliform analyses often detects organisms that are not of sanitary significance. Those familiar with counting total coliform are well aware of the inherent difficulties in this determination.

Results based on the entire total coliform group do have a disadvantage as an "ideal" indicator of fecal pollution because several strains of the group may come from sources other than fecal material of warm-blooded animals and are of no sanitary significance. The enumeration of the fecal coliform component is more specific to coliforms of fecal origin.

EXHIBIT L-1

Bacteriological Quality of the Ohio River
Cincinnati to Markland Dam
1963

Date	Station	Total Coliform 100 ml.	Fecal Coliform 100 ml.	TC:FC Ratio	Flow cfs
10/25	472.4	27,000	5,400	5:1	5,000
10/31	472.4	460,000	2,000	230:1	5,000
11/7	472.4	64,000	4,400	15:1	8,000
10/25	475.1	7,500,000	800,000	9:1	5,000
10/29	475.1	7,400,000	490,000	16:1	5,000
11/4	475.1	330,000	28,000	14:1	6,000
10/25	503.3	4,900	280	18:1	5,000
10/29	503.3	5,200	320	16:1	5,000
11/4	503.3	3,900	170	23:1	6,000
10/25	531.2	78	22	4:1	5,000
10/29	531.2	80	23	3:1	5,000
11/4	531.2	140	19	7:1	6,000

EXHIBIT L-2

Ohio River Pollution Study
Owensboro, Kentucky - Evansville, Indiana
1968

Date		Station	Total Coliform 100 ml.	Fecal Coliform 100 ml.	TC:FC Ratio	Flow cfs
10/10	Ab.	Owensboro, Ky.	5,600	20	280:1	22,000
10/11	Ab.	Owensboro, Ky.	20,000	50	400:1	28,000
10/10	Bel.	Owensboro, Ky.	68,000	2,300	29:1	22,000
10/11	Bel.	Owensboro, Ky.	28,000	670	42:1	28,000
10/10		Newburgh, Ind.	104,000	2,700	40:1	25,000
10/11		Newburgh, Ind.	95,000	2,800	35:1	31,000
10/10		Evansville, Ind.	21,000	370	57:1	25,000
10/11		Evansville, Ind.	150,000	1,300	115:1	31,000

EXHIBIT L-3

Bacteriological Quality of the Ohio River
Pollution Surveillance Stations
1968

Date	Station	Total Coliform 100 ml.	Fecal Coliform 100 ml.	TC:FC Ratio	Flow cfs
7/26	Pa.-W.Va. State Line	2,200	74	30:1	7,500
12/10	Pa.-W.Va. State Line	15,000	700	21:1	pool
7/29	Wheeling	9,400	610	15:1	7,500
12/19	Wheeling	64,000	790	81:1	pool
8/15	Cincinnati	22,000	1,200	19:1	70,000
12/12	Cincinnati	1,600	120	13:1	62,000
8/15	Miami Fort	260,000	26,000	8:1	70,000
12/12	Miami Fort	57,000	14,000	4:1	62,000
8/13	Evansville	27,000	1,600	17:1	115,000
12/4	Evansville	40,000	1,900	21:1	120,000

INDIVIDUAL STATES ADOPTED BACTERIAL CRITERIA

B. Wright

Bacterial Criteria for Recreation
of ORSANCO States

STATE	CRITERIA	APPROVED
Illinois	Primary contact - The fecal coliform content shall not exceed a geometric mean of 200/100 ml, nor shall more than 10% of total samples during any 30 day period exceed 400/100 ml. Secondary contact - The fecal coliform content shall not exceed a geometric mean of 1,000/100ml, nor shall they equal or exceed a 2,000/100 ml in more than 10% of the samples.	Pending Approval
Indian-	Whole body contact - Coliform group not to exceed 1,000/100 ml as a monthly average value during any month of the recreational season; not exceed this number in more than 20% of the samples examined during any month of the recreation season; nor exceed 2,400/100 ml on any day during the recreational season. (Recreational season - April through October.) Partial body contact - Coliform group not to exceed 5,000/100 ml as a monthly average value; nor exceed this number in more than 20% of the samples examined during any month; nor exceed 20,000/100 ml in more than 5% of such samples.	July 18, 1967*
Kentucky	Coliform group not to exceed 1,000/100 ml as a monthly arithmetical average value; nor exceed this number in more than 20% of the samples examined during any month; nor exceed 2,400/100 ml on any day.	March 20, 1969

* Standards are to be reviewed for consistency with present criteria recommendations

STATE	CRITERIA	APPROVED
New York	The monthly median coliform value shall not exceed 5,000/100 ml from a minimum of five samples and not more than 20% of the samples shall exceed 20,000/100 ml.	August 17, 1967*
Ohio	Coliform group not to exceed 1,000/100 ml as a monthly arithmetical average value; nor exceed this number in more than 20% of the samples examined during any month; nor exceed 2,400/100 ml on any day.	March 4, 1968
Pennsylvania	May 15 to September 15 - Not to exceed 1,000/100 ml as an arithmetic average value; not to exceed 1,000/100 ml in more than two consecutive samples; not to exceed 2,400/100 ml in more than one sample. September 16 to May 14 - Not to exceed 5,000/100 ml as a monthly average value, nor to exceed this number in more than 20% of the samples collected during any month; nor to exceed 20,000/100 ml in more than 5% of the samples.	May 21, 1968
Virginia	Not to exceed 2,400/100 ml as a monthly average nor to exceed this number in more than 20% of the samples examined during any month. The preceding values shall not be applicable during nor immediately following periods of rainfall.	January 17, 1969

* Standards are to be reviewed for consistency with present criteria recommendations

STATE	CRITERIA	APPROVED
West Virginia	Coliform group not to exceed 1,000/100 ml as a monthly arithmetical average value; nor exceed this number in more than 20% of the samples examined during any month; nor exceed 2,400/100 ml on any day.	May 21, 1968